WATER

PART A: AQUATIC DIVERSITY
PART B: WATER QUALITY

PURPOSE: To recognize indicators of environmental quality in streams and ponds.

OBJECTIVES: The student will:
1. Identify several aquatic animals and count the types (diversity).
2. Determine the relative quality of a stream or a pond based on chemical and physical tests.

BACKGROUND: The question of water quality on the Fermilab site is of considerable interest to both the physicists and the ecologists. Water is of great importance to the physicists of Fermilab because it is the primary cooling source for computers, superconducting magnets, (beam lines) and the central utility building as an industrial coolant. When water levels are reduced research may be halted until safe levels are restored.

Because of the warmth of the water being cycled into the ponds and streams, an unnatural environment exists in portions of the Lab. This may promote eutrophication, a condition in still ponds which results in an imbalance between plants and animals. Eutrophication generally is due to the natural aging process coupled with the addition of certain types of run off. This is a problem at Fermilab. Unnatural warmth, fertilizers from surrounding farms and industrial pollution are all contributing factors. Increasing goose populations result in abnormally high nitrogen concentrations, also a concern.

Most natural bodies of water capable of sustaining life have pH values ranging from 5.0 to 8.5. Values higher or lower than these or sudden changes in value may be a sign of pollution.

Oxygen enters the water through plant photosynthesis and by diffusion from the atmosphere. It is removed by respiration and decomposition. The amount of dissolved oxygen in a body of water is affected by the temperature, the amount of plant biomass, the depth of light penetration, the flow velocity, and the amount of organic material to be decomposed.

High nitrate concentrations may mean pollution from fertilizers, sewage, animal waste, or the natural decay of dead organisms. At

Fermilab the adjacent farm fields and high goose population increases the importance of monitoring the nitrate concentration. Phosphorus in the form of phosphates enters the water from the same sources as nitrogen in the form of nitrates. High levels of nitrates and phosphates accelerate the eutrophication process.

Carbon dioxide is present in all surface waters usually in amounts less than 10 ppm. It is essential for green plants. Dissolved carbon dioxide has no harmful physiological effect on humans but high concentrations of dissolved carbon dioxide are corrosive and have been known to kill fish.

Alkalinity is the measure of the capacity of water to neutralize acids and is due primarily to the presence of bicarbonate, carbonate and hydroxide ions. High concentrations of these ions may be related to high algal activity. Aquatic plants and animals have varying alkalinity requirements.

In general, hardness is considered to be a measure of the calcium and magnesium content of water. Aquatic plants and animals have varying hardness requirements.

The student researcher will contribute significantly to the ecological awareness of the Fermilab facility in their water quality testing efforts. Data collected at varying sites and compiled over a period of time may reveal trends that will be of considerable benefit to ecologists and other scientists. Since site water sources provide moisture for our deeply rooted prairie plants, this is a vital topic in prairie maintenance. Students need to understand the potential of their research work. Not only will they be improving their scientific awareness and skill levels, but students will be providing valuable data to be used on site. Their accuracy will be dependent on their ability to follow directions and work carefully. Every effort must be made to ensure reliable data.

A wide diversity of organisms generally would indicate better water quality. However, the specific types present need to be considered because some types are more tolerant of pollution than others. The actual biomass or amount living material may increase due to pollution, but the diversity generally goes down.

MATERIALS PART A:

Aquatic Organisms Field Guide (In the Materials Section)
Data Sheets, Aquatic Diversity
Sampling equipment, such as nets, trays, assorted containers
Plastic trays, white
Magnifying lenses
Eyedroppers
Forceps
Fermilab Site Map

PROCEDURE

1. If you choose this activity for your students, all materials and equipment except for student pages will be provided by the Fermilab Education Office. At each sampling site it is necessary to constantly monitor the students behavior. Students are not to go into the water and any rocks that are examined should be returned to their original location.
2. After placing about two inches of water into the plastic trays, students should collect as many types of animals as possible and place them into the trays. Look on and under rocks and logs. Some organisms will be attached to these substrates.
3. Students should complete the Aquatic Diversity sheet (Student page 1).
4. When the observations are completed, all of the organisms should be carefully returned to the stream or pond.
5. Ideally, this activity should be repeated at other sites or at different times of the year. At least one water source should be a running stream. Since the Fermilab field trip allows time for only one site, a school site source might provide an interesting comparison.

DISCUSSION QUESTIONS:

1. Did the sampling site have a high or low degree of diversity? A variety of different kinds of plants and animals is usually an indication of a healthy ecosystem?
2. Does the diversity change with the seasons? How could you find out?

EXTENSION: Construct a food web with the organisms you identified. Make sure you have a producer.

MATERIALS PART B:

Water quality test kit (Fermilab's Education Office uses Hach brand kits)
Thermometer
Meter sticks or tape measure
Fermilab Site Map

PROCEDURE:

1. If you choose this activity for your students, all materials and equipment except for student pages will be provided by the Fermilab Education Office. The chemical tests will be performed by the students under the supervision of Fermilab Education Office Docents as a laboratory activity.
2. Have students follow closely the written and verbal directions provided by the Docents.
3. Complete the Water Quality: Abiotic Data Sheet. Be sure to bring enough copies of the data sheet for your students.
4. To measure the water velocity, mark a 10-meter distance on the shore. Measure the amount of time it takes a floating object (small stick) to go the 10 meters.
5. Ideally, this activity should be repeated at other sites or at different times of the year. At least one water source should be a running stream. Since the Fermilab field trip allows time for only one site, a school site source might provide an interesting comparison.

DISCUSSION QUESTIONS:

1. Why are the ecologists concerned with the water quality at Fermilab?
2. How might the water quality be maintained and/or improved?

Aquatic Diversity

You will undoubtedly find much evidence of animal life at your water site. Be sure to notice specifically WHERE the organism was collected. (swimming in the water, under the rocks, on the surface, clinging to debris)

Select three types of organisms to document on:

1. The organism that is most abundant.
2. The organism that is least abundant.
3. The organism (other than those above) that you believe is the most interesting.

Fill out data sheet for each site.
Data - Site 1

	Sketch	Location	# Found	Possible Identity

How many different TYPES of animals did you find? _____

Data - Site 2

	Sketch	Location	# Found	Possible Identity

How many different TYPES of animals did you find? _____

Water Quality: Abiotic Background

I. Temperature Ranges (Approximate) Required for Healthy Habitat

Warm water	Middle range	Cold
Greater than 20° C	12.8° - 20° C	12.8° C
much plant life	some plant life	stonefly
many fish diseases	some fish diseases	caddisfly
most bass	caddisfly	mayfly
crappie	water beetles	
carp	stonefly	
catfish	mayfly	
bluegill		
caddisfly		

II. pH Ranges for Fermilab Site Specific Organisms

ACID NEUTRAL ALKALINE

1 2 3 4 5 6 7 8 9 10 11 12 13

Bacteria

1.0 ——————————————————————————— 13.0

Plants (algae, rooted, etc.) 6.5 ——————————————————————————— 13.0

Carp, suckers, catfish, some insects 6.0 ——————— 9.0

Bass, crappie, bluegills 6.5 ——————— 9.0

Snails, clams, mussels 7.0 ——————— 9.0

Largest variety of animal (mayfly, stonefly, caddisfly) 6.5 —— 7.5

III. Dissolved Oxygen Requirements for Fermilab Site Specific Aquatic Life
Dissolved Oxygen in Parts Per Million (ppm)

(below 20° C) (above 20° C)

Cold-water organisms Warm-water organisms

6 ppm ——————————————————————————— 5 ppm

IV. Nitrate Nitrogen
A concentration above 0.30 parts per million (ppm) is considered high and can contribute to excessive algae growth.

V. Phosphate Phosphorus
A concentration that exceeds an annual average 0.015 ppm can contribute to excessive algae growth. If the reading is greater than 0.1 ppm, the water has probably become polluted from outside sources.

VI. Carbon dioxide
Most surface waters have carbon dioxide concentrations of less than 10 ppm.

VII. Alkalinity
Alkaline waters reflect a presence of bicarbonate, carbonate and hydroxide ions. Different aquatic species of plants and animals have different alkalinity requirements.

VIII. Hardness
Hard water is caused by calcium and magnesium. Just like alkalinity, different aquatic species of plants and animals have different alkalinity requirements.

Water Quality: Abiotic Data

Identification of sites.

Site 1 _____

Site 2 _____

Comparison of Sites

	Site 1	Site 2
Air Temperature	° C	° C
Water Temperature	° C	°C
Water Velocity	m/second	m/second
O_2 (dissolved)	ppm (O_2)	ppm (O_2)
Nitrate Nitrogen	ppm (NO_3^--N)	ppm (NO_3^--N)
Phosphate Phosphorus	ppm (PO_4-P)	ppm (PO_4-P)
pH		
Carbon dioxide	ppm (CO_2)	ppm (CO_2)
Alkalinity	ppm ($CaCO_3$)	ppm ($CaCO_3$)
Calcium Hardness	ppm ($CaCO_3$)	ppm ($CaCO_3$)

Water velocity can be measured by marking a 10-meter distance near the middle of a shallow stream or on the shore of a deep stream. Throw a buoyant NATURAL object (twig or leaf) in the center of the stream; with a sweep second hand, determine the exact time it takes the object to travel the 10-meter distance. Then divide 10 meters by the number of seconds; this gives you the velocity of the water in meters per second.

Calculations for stream velocity:

$$\frac{\text{10 meters}}{\text{\# of seconds}} = \_\_\_\_\_ \text{ meters per second}$$

Analyzing Your Data

1. Noting the Abiotic Background information on p. 171, which site is the "healthiest" for living organisms?
   Why?

2. If you notice abnormally high or low readings at either site, what is an explanation? Be specific.

   Site 1

   Site 2

3. What ways would you use to make the water at each site a better environment for living organisms?

   Site 1

   Site 2

A Microhabitat: Life in a Log

PURPOSE: To familiarize students with the diversity of organisms utilizing fallen timber as a habitat and contributing to the decomposition of the wood.

OBJECTIVE: The students will:

1. Note the different types of organisms existing on, in and below a rotting log.
2. Study the habitat selected by these organisms and relate this information to the organism's position on the food web.

BACKGROUND: In a natural setting, ground litter (including leaves, twigs, animal excrements and remains, as well as fallen timber) contribute to the ongoing organic recycling necessary to replace nutrients and minerals into the soil. The breakdown of this material is the job of countless microorganisms such as various bacteria, and many macroorganisms, primarily fungi and invertebrates. Through the life functions of these organisms, vital nutrients and minerals are reduced to a form that can be absorbed by the roots of other plants. These plants then become the producers for consumers (herbivores and omnivores) who will continue the cycle.

MATERIALS:
Hand lens
Notebook
Digging blade or knife
Ruler
Collecting containers (bags, jars, etc.)
Forceps
Data sheet

PROCEDURE:

1. Carefully observe the bark. Note color and texture variations. Check for the presence of fungi, lichens, and mosses. Note the relative amount of sunshine and dampness present in the area of the log.
2. Carefully lift a section of bark from the log, try to find a small piece that is easily separated. You may find a wide variety of invertebrates such as beetles, ants, termites, pillbugs, centipedes and a diverse collection of larvae. If fungi is present, webs of yellow and white threads may be seen. These threads are the feeding sources for the fungi. Certain types of bacteria which you cannot see even with your hand lens live along these threads and do the actual decomposing.

3. Carefully observe any visible invertebrate life. Notice any adaptations that help it live in this environment such as exoskeleton, mouth parts and eyes. Be sure to put organisms and bark back as you found them.
4. If the log can be easily lifted and replaced, study the underside. Be sure to observe both the log and the ground under the log. Make comments as indicated above.

DISCUSSION QUESTIONS:

1. How many different organisms did you find? Can you identify them?
2. What are some of the differences between the organisms found in and on the log?
3. Can you tell if the organisms are carnivores, herbivores or scavengers? How?
4. An oak log needs at least 8 to 10 years to completely decompose. How long has the log you are observing been disintegrating?
5. As you observed the underside of the log, did you see any indication that the soil was becoming enriched? Describe what you observed.
   How do you think new soil forms?

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4. If the log can be easily lifted and replaced, study the underside. Be sure to observe both the log and the ground under the log. Make comments as indicated above.

DISCUSSION QUESTIONS:

1. How many different organisms did you find? Can you identify them?

2. What are some of the differences between the organisms found in and on the log?

3. Can you tell if the organisms are carnivores, herbivores or scavengers? How?

4. An oak log needs at least 8 to 10 years to completely decompose. How long has the log you are observing been disintegrating?

5. As you observed the underside of the log, did you see any indication that the soil was becoming enriched? Describe what you observed. How do you think new soil forms?

Name_____

Life in a Log Data Sheet

SURFACE

Organism	Description and Drawing (Include measurements.)	Adaptations

UNDER THE BARK

Organism	Description and Drawing (Include measurements.)	Adaptations

UNDER THE LOG

Organism	Description and Drawing (Include measurements.)	Adaptations

Using the wanted posters, attempt to identify the organisms you observed.

Prairie Insects

PURPOSE: To collect and examine insects found on leaves and in the air in the prairie plant community.

OBJECTIVES: The student will:
1. Identify some of the insects native to the Fermilab prairie.
2. Document specific insect species in Plot 16.
3. Note adaptations of insects which help ensure their success in this environment.

MATERIALS:
Sweep nets
Wide mouth jars
Hand lenses
Insect Field Guides

PROCEDURE:
1. Students will collect insects by making wide sweeps with nets, fanning out in several directions within an area.
2. Grasping the center of the net to contain insects in the bottom, students will carefully deposit collections in a jar.
3. *Examine the contents of the jars and record on your data sheet.*

DISCUSSION QUESTIONS:
1. What insect or type of insect was most prevalent?
2. Did anyone notice wider diversity than others? Why do you think *this did or did not happen*?
3. When you examined the insect collections, were there any species that were obviously different, yet had many of the same characteristics (hard shells, bright colors, lacy wings, long legs, etc.)?
4. Referring to question 3, why do you think these insects have these characteristics? Give at least three.
5. The above questions refer to adaptations. These adaptations help ensure the success of these organisms. What are some adaptations you have to help ensure your success in your environment? Name at least three.

Prairie Insects Data Sheet

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3. Examine contents of jars and record on data sheet.

Collect, examine and classify by placing in groups the insects you have collected. Record your results below.

INSECT	PLOT NUMBER	NUMBER FOUND	ADAPTATIONS

INSECT	PLOT NUMBER	NUMBER FOUND	ADAPTATIONS

The Twig Tale

PURPOSE: To provide students with a winter activity that will improve their observation skills.

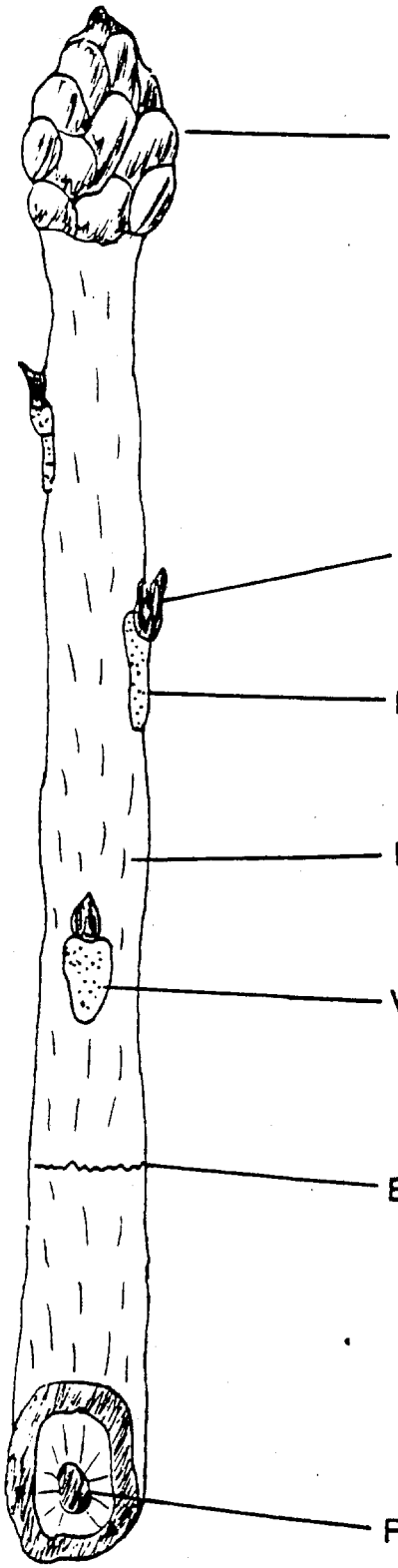
OBJECTIVES: The students will:
1. Identify trees during the months when the leaves are not present.
2. Learn the parts of a twig.

MATERIALS: Winter tree finder
Hand lens
Twigs

PROCEDURE:
1. If students are to become familiar with the use of a key, they need an opportunity to study it. A classification activity should be done prior to this activity.
2. The students should be provided with twigs and a hand lens, and should be able to identify the parts listed on the following page. A transparency can be made of this page.

DISCUSSION QUESTIONS:
1. What do you think will happen if the terminal bud of the twig is cut off?
2. What do you think will grow from the lateral bud?
3. Would a twig survive if the lenticels were covered with a tar-like substance?
4. What are the tiny dots inside the leaf scar?
5. About how old is your twig?

Twig Key



In the spring the twig will grow longer from this bud. It is often much larger than the lateral buds, but is absent from the twigs of some trees.

Branches grow from the lateral or side buds. There is usually less growth here than at the terminal bud.

This scar indicates where a leaf was attached last summer.

These cork-filled pores permit the green, living inner bark to breathe.

These dots on the leaf scars are the broken-off cork-filled ends of the tubes that supplied water to the leaf.

This scar indicates where last year's terminal bud was. The distance from this scar to the end of the twig (terminal bud) represents one year's growth.

The pith is the soft inner core of the twig.

Baked Potato Invertebrate Trap
(Extension of the Invertebate Lab)

PURPOSE: The purpose of this activity/lab is to capture and examine invertebrates in the soil.

OBJECTIVES: Students will identify organisms found in the soil.

MATERIALS:
Baked Potatoes - halved - three halves per group
Small plastic "baggies"
Dissection probes, toothpicks or shish-kabab skewers
Hand lenses or dissection microscopes

PROCEDURE:
1. Prepare baked potatoes and place cut side down on a section of moist soil.
2. Repeat in well-drained and dry soil.
3. Allow to remain in place 24-48 hours undisturbed.
4. Remove potato carefully from soil and examine. (Invertebrates may have penetrated interior of potato - use probe to examine.)
5. Use hand lenses to observe. Classify according to type. (Insect, worm, snail, etc.)
6. Collect group data and build conclusion based on all soil types.

DISCUSSION QUESTIONS:
1. Does there appear to be a difference in the types of organisms at each site? Explain.
2. Why might such differences occur?
3. Compare these organisms to those discovered with Berlese Funnel. Are there any differences? Why or why not?
4. Can you think of any other "bait" for invertebrates? Name at least three. What might you find?
5. Why are these organisms in the soil?
6. Are soil invertebrates considered good or bad? Explain.
7. Did the type of soil make a difference in the number or type of organisms?

Baked Potato Invertebrate Trap
Data Sheet

List and describe organisms found in potato.

Sample Location _____ (prairie, forest, school lawn, etc.)

Name of Organism	Sketch	Number Found	What Do They Eat?	NICHE: Scavenger, Herbivore, Carnivore, etc.

Thinking Environmentally

PURPOSE: To gain information concerning changes in attitude about wildlife and environment.

OBJECTIVES: The student will be able to:

1. Give an example of a change in attitudes related to an animal and/or the environment.
2. Describe factors which may influence changes in attitude.

BACKGROUND: Attitudes toward wildlife, the environment and appropriate uses of natural resources have changed and continue to change over time. They also vary greatly from culture to culture.

MATERIALS: Paper
Magazine and newspaper articles of an environmental nature

PROCEDURE:

1. Initiate a discussion with students about whether or not they think people's attitudes about some subjects might change, for example over a generation. Fashion in clothing, furnishing and food might serve as examples to begin. Ask them about changes in attitudes in wildlife, the environment, uses of natural resources and lifestyles. Discuss their suggestions and list any topics they may suggest.
2. Ask the students to compile a notebook or a bulletin board of articles from newspapers and magazines concerning wildlife or the environment. If the student is unsure of an article, have the student bring it in.
3. Ask the students to work in groups of two to four. Students should then generate a list of questions relating to wildlife and the environment that they might ask of adults or friends in their community or family. For example:
   - How do you feel about wildlife?
   - Does wildlife live in your neighborhood?
   - Did wildlife live in your neighborhood when you were growing up?
   - What problems, if any, involving wildlife are you concerned about?
   - What recommendations, if any, do you have for solving these problems?
   - What are the general changes, if any, do you think there are in society's attitudes toward wildlife and the environment, perhaps some changes you think are good and some you do not?

4. Review the questions generated by each group of students before they conduct their interviews.
5. Ask the students to interview at least one long-living person in their community.
6. Ask the students to interview each other.
7. Suggest that the students interview others, such as, wildlife managers, members of city council, farmers, ranchers, animal welfare groups, hunting club members, private conservation group members and other community representatives.
8. Compile the results of the interviews. Have the students summarize the results of their interviews in a one-page format.
9. Discuss with the students their findings, including what changes on attitudes have taken place, if any, and what factors contribute to any changes in attitudes that they have identified.

DISCUSSION QUESTIONS:

1. Describe how you think most people form their attitudes, what they know and how they feel about animals..
2. Give two examples of attitudes: what they know and how they feel about animals that you have reasons to believe are based on wrong information or not enough information.
3. Give an example of a change in attitude about an animal or issue that has occurred in this country during the past 100 years. How did this change come about?

EXTENSION: Identify a local controversy involving or affecting wildlife or other natural resources. Fact find. How did it develop? What attitudes and information are involved? What possible solutions are available?

SUGGESTED READINGS:

Wild Strawberries, by Shel Silverstein.
Where the Wild Things Are, by Maurice Sendack.

Rebuilding: Why? Frame #s [5576 - 6788] 40 seconds

Rebuilding a prairie offers educational opportunities to study a vanishing ecosystem. Aesthetic values and historical significance are discussed. The environmental and practical reasons follow.

Environmental Reasons Frame #s [6789 - 8870] 1 minute 8 seconds

Prairies allow for plant and animal diversity which leads to a healthy ecosystem. The prairie's impact on the environment (soil and air) and the prairie as a laboratory is discussed.

Prairie Plantings

PURPOSE: To grow prairie plants from seeds.

OBJECTIVES: The students will:
1. Successfully produce a prairie plot from seeds provided.
2. Recognize the needs of prairie plants.

BACKGROUND: A strong root system will develop during the first growing season. Once established, the plant should thrive on little or no care. These plants are better adapted to the region and will provide the best chances for success.

MATERIALS: Prairie seeds
Sterilized garden soil
Wooden flats/or suitable planting containers
Water (NOT softened)
Suitable outdoor growing area for containers
Suitable permanent outdoor site

PROCEDURE: Potting Container: Outdoors - A wooden flat or large pots may be used.
Indoors - A four-inch plastic pot, or larger, would be desirable. An 8 oz. recycled yogurt container with adequate drainage would be sufficient and can save space. All containers must have proper drainage.
Permanent outdoor site - Choose a site that has full sun. The size of your prairie plot is not critical. The site should be of manageable dimension, be open to burns and be accessible to hose for watering.
Soil: For best results, use regular garden soil that has been sterilized in a microwave thoroughly to destroy weed seeds. Commercial potting soil is not recommended because it may not duplicate garden soil or prairie soil adequately. Use approximately five cups of soil in the microwave for five minutes (or one cup per minute).
Stratification: Most prairie seeds need at least two months of cool, moist conditions just like they would be exposed to under natural conditions. Mix seed with an equal volume of moist sand or vermiculite. Place a plastic bag, seal and refrigerate below 40 degrees F for two months.
Planting Seeds: Use fresh, local seeds. Plant larger seeds no more than 1/2" deep. Smaller seeds should be sprinkled on damp soil. Do not allow soil surface to dry out.
Outdoors - This can and should be a student activity. Divide up your site into individual plots (a square meter per student or small

group). Have students prepare the ground for planting using hand gardening tools. They should remove as much growth as possible, but getting down to the barren soil is not necessary. Prairie plants are native species and will eventually phase out nonnative types. A paper cup (6-8 oz.), filled with seed, per square meter is sufficient. Spread the seed out evenly by hand broadcasting. Firm them into the soil by hand raking and patting. Water the seeds and do not allow the soil to dry out until germination of seeds has been well established.

Watering: If soil is watered before seed planting, then seeds will not become exposed or wash away. If watering is needed, it would be advisable to water from the bottom by placing the container or pot in a saucer of water. Softened water (the product of a water softener) should be avoided.

Germination: Prairie seeds may take from two to six weeks to germinate, or possibly longer. The seed leaves will appear first, followed by the true leaves. At the growth of the first true leaves, transplanting to individual containers is recommended.

Growth: The growth of stem, leaves, and flowers usually occurs at a slower rate than the developing root system. Flowering usually occurs after the first growing season.

Lighting: Natural daylight would be the most desirable. Grow-light fluorescent bulbs with a timer set for twelve hours of daylight or more is sufficient. Seedlings should be as close as possible to the light source, or they may grow long and inferior.

Hardening: Prairie plants thrive in full sunlight. Indoor seedlings should be gradually "hardened" by exposing them to the morning sunlight for several days before planting in full sunlight.

Transplanting: Seedlings transplanted with a ball of soil attached to their root systems will suffer less shock, and survival will be greatly increased. Plant seedlings 8 to 12 inches apart in full sun in well-drained soil. Water as needed. The last half of the month of May is ideal because of cooler temperatures and moist soil as well as avoiding a late frost.

Biotics: Plants and Animals Frame #s [26633 - 28716]
1 minute 8 seconds

The ecological significance and impact on prairies of food webs, diversity of habitat and organisms, and fire are explained. The prairie's destruction has resulted in monocultures and fields of foreign weeds.

Abiotics: Natural Factors Frame #s [36231 - 37561]
43 seconds

Abiotic factors include the sun, wind, water, soil, and fire. These factors along with weather are responsible for shaping the prairie.

Seed Dispersal

PURPOSE: To familiarize students with a variety of common seeds and investigate the different mechanisms of dispersal.

OBJECTIVES: The students will:
1. Be familiar with mechanisms of seed dispersal.
2. Better understand how certain plants have adapted to the environment.

BACKGROUND: Wildlife interactions contribute to the diversity and balance of ecological systems. One compelling example is the process of seed dispersal. Many seeds are carried by animals, whether in the coats of furbearing animals carried and dropped by some birds. Other seeds are adapted to be carried or scattered by wind, water or gravity.

If commercial seeds have been treated with fungicide, they should be washed before handling.
Remind students NOT to overhandle prairie seeds as they will be used for planting.

MATERIALS: Packet of prairie seeds, and other types of seeds
Plant classification guides
Hand lens
Picks or probes to manipulate prairie seeds without handling.
*Data sheets
Nonprairie plant seeds provided by teacher or student
Method of Dispersal:
Wind - ash, elm, maple, sycamore, dandelion
Animal - acorn, beggar tick, magnolia, sycamore, burr, peach pit, blackberries
Gravity - acorn, magnolia, coconut, peach pit, pine
Water - coconut
Mechanical forces - pine, bean, pea

PROCEDURE:
1. Stations should be set up so that students can rotate from one to the other every three minutes. Each station should include a number, the common name of the plant, a hand lens, scientific name of the plant, several seed samples for handling and one seed affixed to the station number.
2. Students are to fill in the data sheet as they rotate from station to station. Students may be in pairs or cooperative learning groups.

DISCUSSION QUESTIONS:

1. *What would happen if all of the seeds from an adult plant* attempted to grow near the parent plant instead of being scattered (dispersed)?
2. What characteristics would a seed need if it was dispersed by the wind? gravity?
3. What appendages would a seed need if it was dispersed by "hitchhiking" in a dog's fur?
4. Explain how the seeds you observed has adapted to the environment.

EXTENSIONS:

1. Invent a seed.
2. View pollen grains under the microscope; compare size with a seed from the same plant.
3. Have student bring in other seeds home and explain the dispersal mechanisms.

Seed Collecting and Planting
Frame #s [12768 - 15777] 55 seconds

Seed collecting from nearby prairies and the procedures for preparing and planting the future prairie are shown.

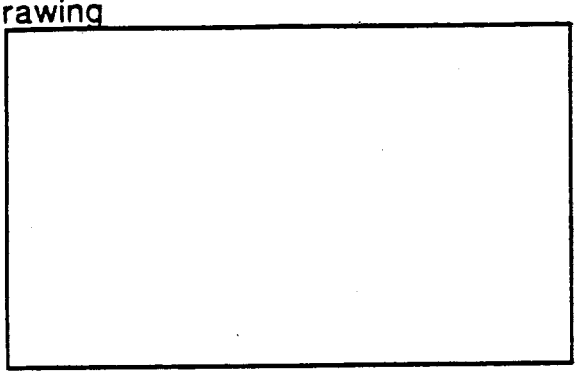
Seed Dispersal Frame #s [43101 - 43910] 26 seconds

Seeds are dispersed by wind, water, animals, or mechanical means. This helps plant species to expand their territories.

Seed Dispersal Data Sheet

Station Number _____

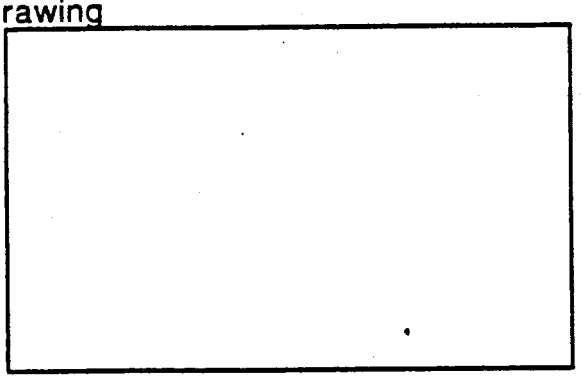
Drawing



Common name _____
Scientific name _____
Probable means of dispersal _____
_____
_____

Station Number _____

Drawing



Common name _____
Scientific name _____
Probable means of dispersal _____
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Station Number _____

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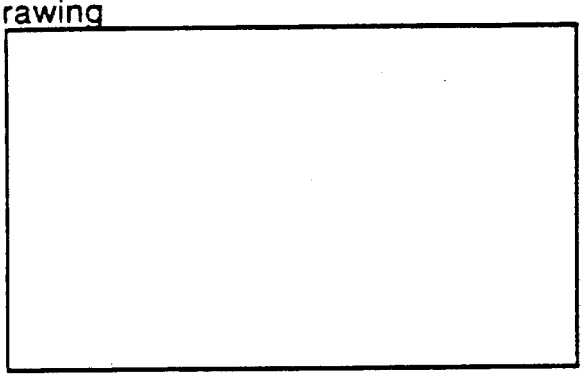
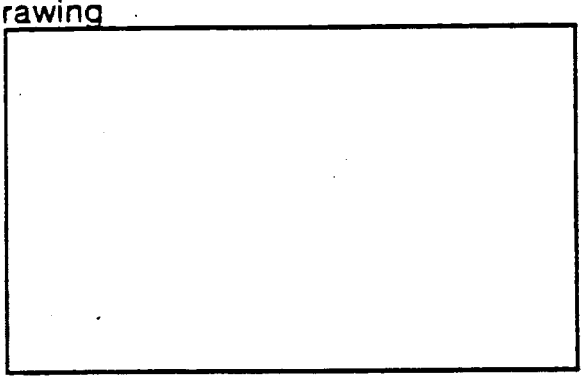


Common name _____
Scientific name _____
Probable means of dispersal _____
_____
_____

Station Number _____

Drawing



Common name _____
Scientific name _____
Probable means of dispersal _____
_____
_____

Comparison of School and Fermilab Data

PURPOSE: To compare school site and Fermilab observations and data.

OBJECTIVES: Students will:
1. Note differences between school site (Eurasian) grasslands and restored prairie at Fermilab.
2. Determine positive and negative attributes of both areas.
3. Develop an appreciation for the diversity and unique nature of organisms on the Fermilab prairie site.

BACKGROUND: Various lab experiences have been designed for use on and off the Fermilab site. Depending on equipment available on school site, an interesting comparison of various aspects of these ecosystems could prove beneficial in the conceptualization of the unique nature of the prairie.

MATERIALS: Completed student data sheets for any or all of the following:
1. Pollinators and Consumers
2. Quadrat Study
3. Abiotic Study
4. Water: Aquatic Diversity; Water Quality
5. Leaf Litter

Comparison student data sheet master

PROCEDURE:
1. Complete both a school site and prairie study of a specific lab.
2. Put students in small groups and provide each group with copies of all completed data sheets.
3. Have groups complete comparison data sheet for EACH lab INDEPENDENTLY.
4. Discuss results. Use board or overhead projector to itemize similarities and differences.
5. Develop a class conclusion establishing differences and similarities between Eurasian site and prairie.

DISCUSSION QUESTIONS: Utilize with EACH lab INDEPENDENTLY.
1. How are the sites similar? Be specific.
2. How do they differ? Be specific.
3. List three attributes/disadvantages of each.
4. Should prairies be preserved and/or restored? Give at least three reasons for your opinion.
5. Someday you may be a parent. What will you tell your child about the prairie? Be sure to include at least three important points. Have students role play from different perspectives.

Particles and Prairies - A Research Experience for Middle School Students (Combined Motion Sequences)
Frame #s [03692 - 53728] Approx. 28 minutes

This is a combination of all motion sequences and includes the history, ecology, research and restoration of the Fermilab prairies. Teachers should note that all of the following motion sequence presentation topics are shown.

Comparison of School and Fermilab Data

Name_____

Title of Lab Experiment_____

	School Site	Fermilab
Similarities		
Differences		
Positive Attributes		
Negative Attributes		
Surprises!!		

SOIL STRUCTURE

SOIL STRUCTURE

BACKGROUND: Naturally formed soils have similar basic structure. This can be seen in an excavation that is more than five feet deep or cut for a roadway extending through a hillside.

The relatively thin dark layer of topsoil lies above a lighter-colored subsoil. Below the two upper layers is one of bedrock (dolomite or limestone in our area), usually five feet or more below the surface.

PROCEDURE:

1. Fill a jar three-fourths of its height with water. Add a selected soil sample to raise the level so that the jar is about full. Tightly screw on the cap and shake vigorously. Allow the jar to stand quietly until all the soil solids have settled. (See diagram.)
2. Measure the depth of the different layers, in centimeters, and record, noting that good topsoil consists of particles of fine sand, some clay and humus.

DISCUSSION QUESTIONS:

1. Take a small amount of material from each layer. Rub it between your fingers. How are the textures different?
2. Which layer would hold water best? How do you know?

EXTENSION: Attempt this method with another soil type.

Soil Research Frame #s [49988 - 51125] 37 seconds

Research has shown that the prairie has improved the soil quality at Fermilab. Prairies increase the basic unit of soil called soil aggregates. Soil aggregates stabilize the soil, resist soil breakdown and erosion, and stimulate plant growth.

The Particles and Prairies Videodisc has a series of still pictures entitled "Soil Analysis and Techniques" that may enhance this activity. Refer to the Videodisc Guide.

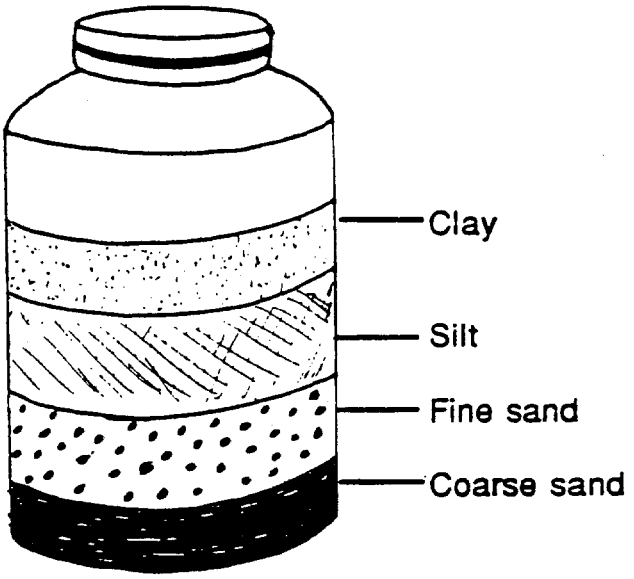


Figure 1. Separation of layers of materials that make up a sample of soil. Other soils will show other layers and different thicknesses of the layers. Why do the layers separate this way?

Real Estate Ad - How to Sell a Prairie

PURPOSE: To develop a sales poster for one acre of tall grass prairie.

OBJECTIVES:
1. Students will illustrate beauty and drama of the prairie as they see it.
2. Students will prioritize attributes of the prairie.
3. Students will project the potential of the prairie from economic and aesthetic aspects.

MATERIALS:
Art supplies as designated by teacher
Student Page
Posterboard - (Assign a uniform size to be used by all students.)

PROCEDURE:
1. Instruct students to complete student page.
2. Include all information on poster in a creative manner.
3. Discuss prairie attributes. (Some students will focus on flora and fauna; others will see potential as homesite or farmsite, etc.).
4. Encourage creativity, color and diversity.

DISCUSSION QUESTIONS:
1. If a neighbor had all his grass lawn removed and planted with prairie plants, what would your reaction be?
2. Our world is facing a severe food shortage. How might prairie restoration be of benefit? Is this practical?
3. Is the prairie worth restoring? Why or why not?

EXTENSION: With a partner, role play these two situations. Be sure to exchange responsibility in the primary role.

1. You are a prairie advocate speaking to an individual who does not know what a prairie actually is. Try to convince the person that prairies should be preserved and restored.

2. You are a parent in the year 2005 A.D. Your child asks you to describe a prairie. You want your child to appreciate a prairie. You want your child to appreciate the uniqueness of the prairie. What do you say?

Be prepared to repeat your role playing in front of the class.

Name _____

Real Estate Ad

Congratulations! You are a successful real estate agent who has acquired a prairie listing. Knowing about the wonderful qualities of the prairie, you want to advertise in the best possible way. Use this sheet to help you organize your information and create a brochure designed to influence even the most skeptical buyer to purchase this acre of prairie.

Size: 1 Acre

Cost: _____

Qualities of Prairie

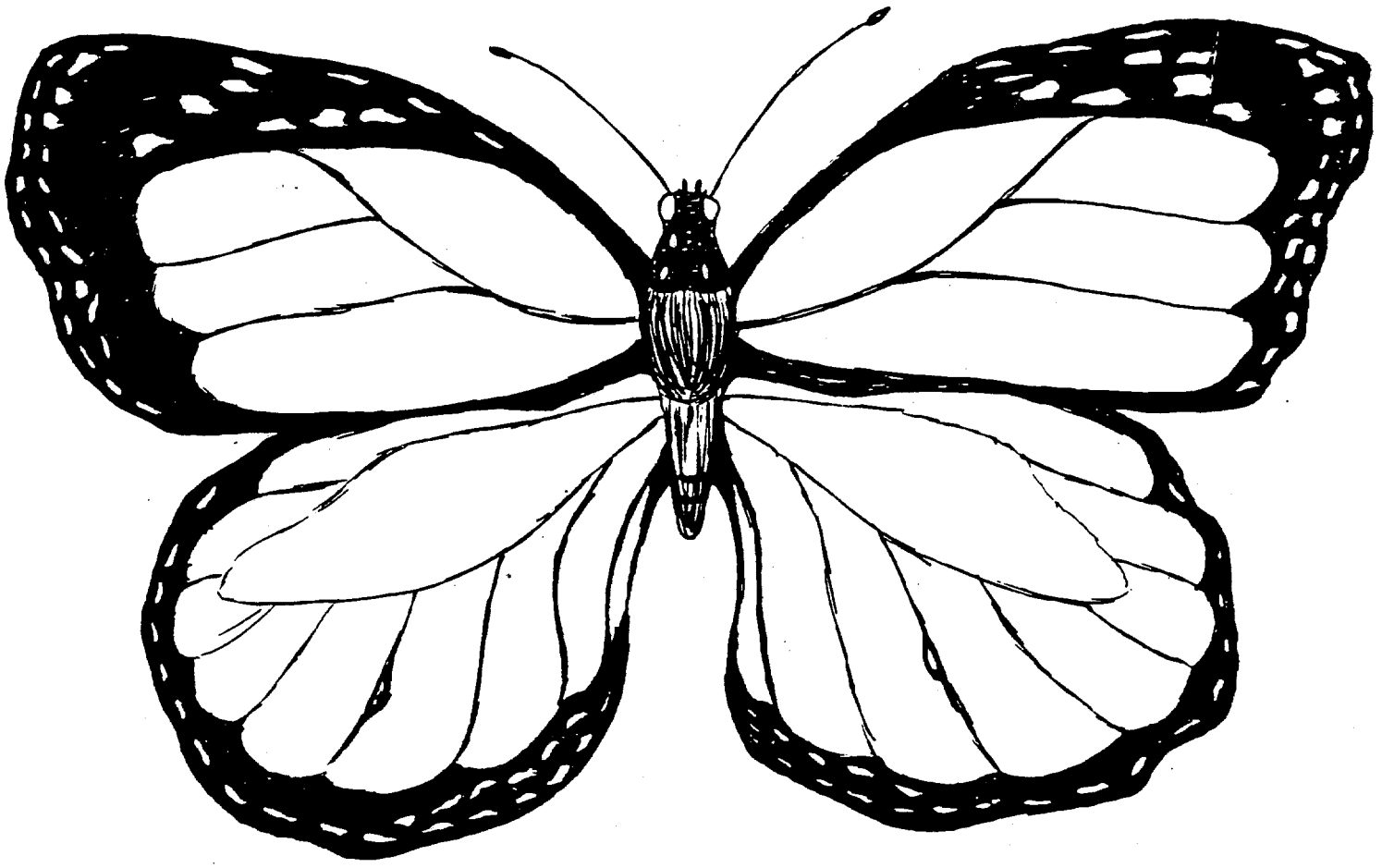
A. What is on this acre of prairie?

B. How could this prairie be used?

C. Future value of prairie?

Be sure to provide a colorful picture of the prairie in its present state and/or your interpretation of what the prairie could look like in the future.

Interdisciplinary Mini-Unit
Monarch Butterfly



Interdisciplinary Monarch Mini-Unit
Developed by Team I
Madison Junior High
Naperville School District 203

Lyn Crabbe
Mary Currier
Larry Cwik
Patricia Franzen
Gundy Sprouse
David Weiseman

Interdisciplinary Activities

Science:

2 days - Collecting, rearing and releasing Monarch butterflies.
Journal time.
Life cycle of the Monarch - science journal.

Math:

1 day - Calculating the distance traveled by a Monarch butterfly.
Calculating the mass and area of a flock of Monarch butterflies.

Social Studies:

1 day - Mapping the migratory routes of the Monarch butterfly.
Comparing climate, topography, terrain, of summer and winter sites.

Reading/English:

1 day - Monarch Poetry.

3 days - Creative story from Monarch's perspective.

The concept of an integrated Monarch unit originated at Madison Junior High in Naperville School District 203. Their unit has been modified to better fit the Particles and Prairies format.

Refer to Miracle of the Monarch's, by Kim Harris, and Monarch Butterfly, Illinois Department of Conservation, for additional background.

Science Component

1. Journal Record Keeping - Allow 5-10 minutes on Mondays and Fridays for journaling. If daily journals are part of your interdisciplinary unit, this is a perfect option.

2. Collecting, rearing and releasing of Monarch butterflies must be initiated mid-August through early September with the collecting of eggs and larva. Refer to "Tips for Collecting and Rearing Monarchs" for specific instructions.

3. Observe stages of Monarch metamorphosis using collected specimens. Follow up with Life Cycle Sequence Puzzle Page.

Tips for Collecting and Rearing Monarchs

In middle Illinois the appropriate time of locating monarch eggs and larvae is mid-August until the first week in September. Once you are able to identify the monarch eggs, they are easier to obtain in greater number than the caterpillar. Also eggs hatched in captivity seem to have less disease and parasites.

Locate a patch of milkweed with very few aphids and ants. Monarchs are rarely found on insect-infested plants. When looking for eggs and larvae, gently bend the milkweed stalk downward so the underside of leaves is showing. This is where most of the monarch eggs and caterpillars will be found. When an egg or caterpillar is located, remove the leaf it is on and place the "critter" and leaf in a container with a lid (i.e., butter tub, ice cream container, etc.). All monarchs that are found during your search may be stored in the same container until you get back home or to school.

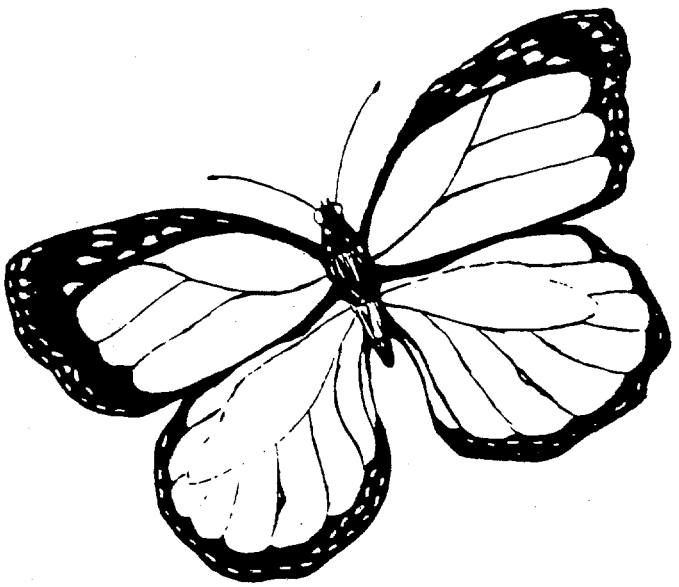
When you arrive at home or school place the caterpillars on freshly cut milkweed stalks placed in some water. Pop bottles work quite well. Watch the stalks carefully for freshness. Changing the caterpillars to fresh stalks at least every other day is recommended. If the milkweed is old, tough, and dry, the caterpillars will be unable to feed and will starve to death. If the caterpillar is two or more centimeters long, pick it up gently and place it on its new home. If it is smaller, cut a section of the leaf with the caterpillar on it and place it on the fresh plant. Be sure to put newspapers under them . . . you do want them paper trained. Be sure to change the paper frequently to help eliminate the chance of disease.

After caring for the newly found caterpillars it is time to care for the eggs. Select a leaf that you found with an egg on it. Cut out a section of leaf with the egg on it and place them on a fresh milkweed stalk. Another way to deal with the unhatched eggs is to cut a section of leaf with the egg still attached and place it in the lid of a box along with all other eggs. You can quickly observe the eggs to determine which are ready to hatch. When the egg turns grey or dark at the top, the head is developing and will soon hatch. At this point in time, place the egg and piece of leaf it is attached to on a fresh milkweed stalk. The "box lid" method must be monitored closely; otherwise the caterpillars will hatch and have no food source.

Shari Morkin
Bloomington, Illinois

** Monarch Series (egg to butterfly) **

Monarch Egg on Milkweed (1.2 x .9 mm)	2197		Monarch Chrysalis or Pupa	2229	
Monarch Egg on Milkweed (1.2 x .9 mm)	2201		Monarch Butterfly Emerging from Chrysalis	2233	
Monarch Caterpillar Newly Hatched (.5mm)	2205		Monarch Butterfly Emerging from Chrysalis	2237	
Monarch Caterpillar or Larva	2209		Monarch Butterfly Drying Wings on Chrysalis	2241	
Monarch Caterpillar or Larva	2213		Monarch Butterfly Drying Wings on Chrysalis	2245	
Monarch Caterpillar Preparing to Form Chrysalis	2217		Monarch Butterfly Drying Wings on Chrysalis	2249	
Monarch Caterpillar Changing to Pupa (Chrysalis)	2221		Monarch Butterfly Drying Wings on Chrysalis	2253	
Monarch Chrysalis or Pupa	2225		Monarch Butterfly Emerged	2257	



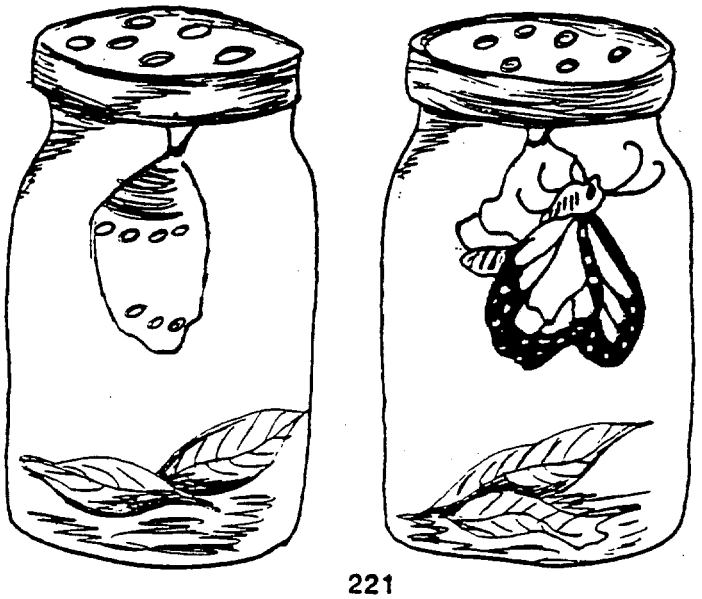
Journal Record Keeping of Monarch Data

Entomologist _____

Science Period _____

Watch the development of our team's Monarchs and listen carefully to your teacher's explanations. Twice a week--on Monday and Friday--write a Journal Record of your observations of the growth of the chrysalis. Feel free to take preliminary notes!

Include the following:
Size
Color
Shape
Distinguishing Characteristics



The Life Cycle of a Monarch Butterfly

Entomologist _____

*Science Period*_____

Arrange the order of events in a Monarch's life in proper sequence using numbers 1-10.

_____ The butterfly splits the chrysalis and begins to enter the world outside the cellophane-like casing.

_____ The caterpillar's skin splits open and a black hook appears. The hook takes the place of the caterpillar's legs that drop off with the skin.

_____ The female Monarch lays tiny green or yellow eggs on milkweed leaves.

_____ After a few hours the Monarch's wings are completely dried and ready for exercise.

_____ After about 1-1/2 weeks (10 days), black and orange wings can be seen through the transparent chrysalis. The butterfly is nearly mature.

_____ A small caterpillar (larva) hatches from the egg. Its only job is to eat for about 2 weeks. The caterpillar will shed its skin several times during this period.

_____ At this point, the wings are crumpled and quite small. Fluid from the insect's body is pumped into the wings. As the veins fill with this fluid, the wings expand and stiffen.

_____ The caterpillar hangs upside down like the letter "J." As the Monarch's days as a caterpillar ends, its antennae droop and it prepares for a change.

_____ The caterpillar becomes enclosed in the chrysalis (pupa) and becomes a "little green house with gold nails."

_____ The caterpillar grows to about 2" long. At this point, it stops eating and spins a silk-like button to attach itself to a spot.

The Life Cycle of a Monarch Butterfly

Arrange the order of events in a Monarch's life in proper sequence using numbers 1-10.

8 The butterfly splits the chrysalis and begins to enter the world outside the cellophane-like casing.

5 The caterpillar's skin splits open and a black hook appears. The hook takes the place of the caterpillar's legs that drop off with the skin.

1 The female Monarch lays tiny green or yellow eggs on milkweed leaves.

10 After a few hours the Monarch's wings are completely dried and ready for exercise.

7 After about 1-1/2 weeks (10 days), black and orange wings can be seen through the transparent chrysalis. The butterfly is nearly mature.

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6 The caterpillar becomes enclosed in the chrysalis (pupa) and becomes a "little green house with gold nails."

3 The caterpillar grows to about 2" long. At this point, it stops eating and spins a silk -like button to attach itself to a spot.

The Particles and Prairies Videodisc has a series of still pictures entitled "Monarch Series - Egg to Butterfly" found under the "Prairie Invertebrates" that may enhance this activity.

Entomologist_____

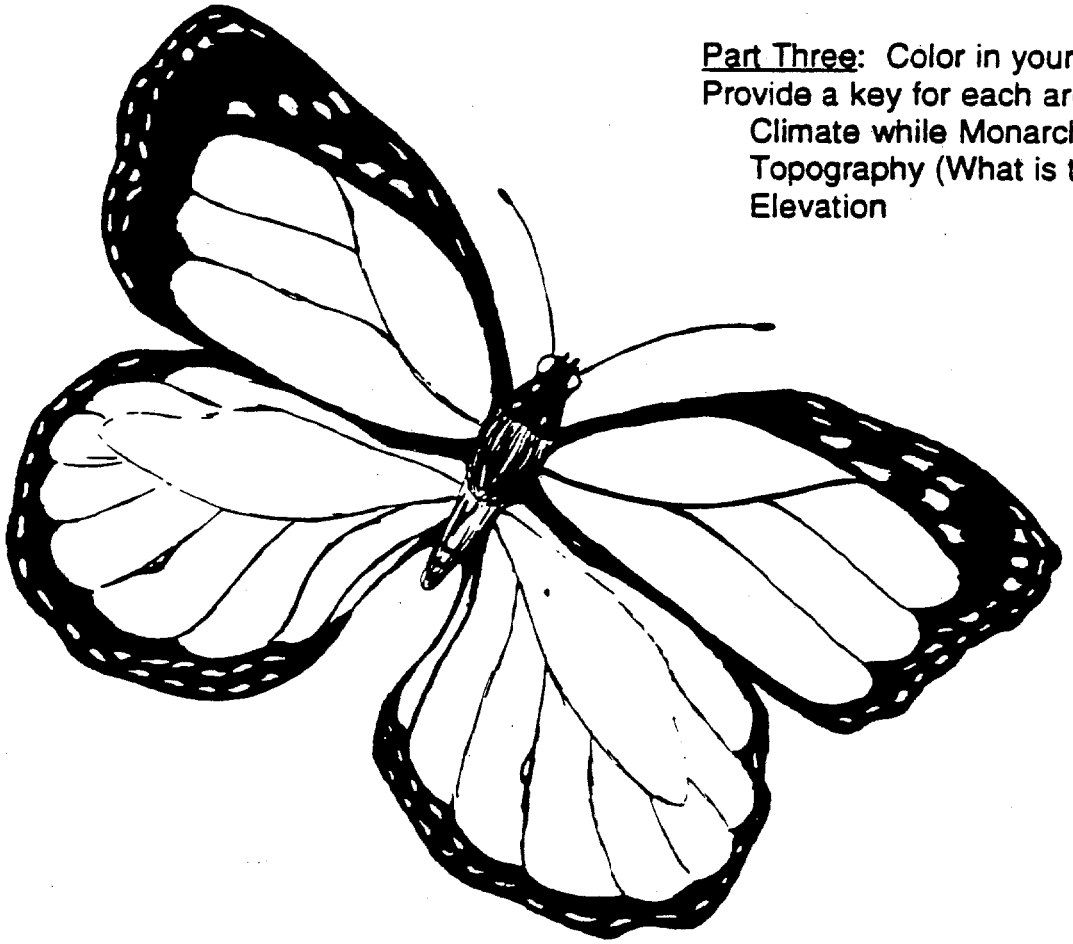
Social Studies Period____

Monarch Migration Routes

Part One: Locate the following on your copy of the North American map:

Illinois	Texas	California
Florida	Mexico	Canada

Part Two: Plot the Southern migration routes taken by the monarch butterflies so that they can hibernate for the winter. In math class you will produce a key plotting total distance traveled.



Part Three: Color in your map appropriately. Provide a key for each area showing:
- Climate while Monarchs are present
- Topography (What is the land like?)
- Elevation

Map of North America

Entomologist_____

English Period_____

Poetry

Create a poem about the Monarch using one of these formats. Be sure to notice how the examples match the instructions for each type of poem.

Haiku

- Three lines of 5, 7 and 5 syllables.
- Emphasis on syllables - NO RHYME.

The flighty Monarch
orange and black fast rushing wings
delicate beauty

Cinquain

- The term cinquain is taken from the French and Spanish words for five.
- Five lines which may be syllablic or word ordered. (Example is word ordered.)
- Each line has a specific formula:

Line 1 - 2 syllables (or words) Title
Line 2 - 4 syllables (or words) description of the title
Line 3 - 6 syllables (or words) description of action
Line 4 - 8 syllables (or words) description of feeling
Line 5 - 2 syllables (or words) restatement of title

Monarch larva
light green and gold,
creeping, crawling, munching, moving, curving, climbing
single-mindedly, systematically devouring the stately, fragrant milkweed plant
Immature Jewel

Diamante

- A diamond-shaped poem depicting extremes.
- The parts of speech patterns are very specific.

Noun
adjective, adjective
participle, participle, participle
noun, noun, noun, noun
participle, participle, participle
adjective, adjective
noun

caterpillar
green, gold
eating, growing, slowing
warmth, milkweed, prairie, chrysalis
resting, changing, emerging
drying, fluttering
butterfly

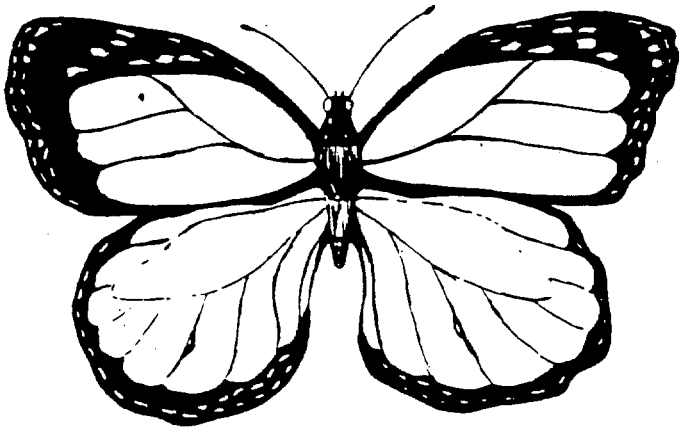
Entomologist _____

English Period _____

Monarch Creative Writing: 1st Person

You are going to write a first person narrative from the Monarch butterfly's point of view. It will be your job to tell the story of the Monarch from its point of view. Since this will be an extended writing, it's important to complete many pre-writing activities in all your classes. That way you can easily become the Monarch. Over the next few days jot down any observation, thoughts, and questions that occur to you. You are also welcome to complete some research on your own! Monarch poetry and journal entries will help you as you create your story.

Complete your rough draft on your own paper.



Monarch Story Editing

Entomologist_____

English Period_____

Personal Proofreading

Proofread and edit for the following:

Format of Story:

[ ] The story is between one and two pages--not just one page!
[ ] The story covers the entire life cycle--from egg to butterfly.
[ ] The story is told from the first person point of view--"I flew away."
[ ] The story has a creative name.

Additions to Story. After you complete your rough draft, consider the following:

[ ] Choose at least one part of the story and expand on the storyline--in other words, make it longer!
[ ] Add FIVE additional descriptive adjectives--words telling *Which* one? *What kind? How many?, or How much?*
[ ] Add FIVE additional descriptive adverbs--words telling *How?, When?, Where?, How often?, or To what extent?*
[ ] Add a simile--a comparison of two objects using *like, as, or than*--For example, "I flew **like a booming jet plane** on my way to California."
[ ] Add personification--a phrase that gives an inanimate object living characteristics--For example, "The flower hugged me as I was munching its nectar."
[ ] Add alliteration--a phrase where the beginning sounds of world are the same--For example, "The wind whipped the milkweed plant as I wriggled along it."

For Extra Credit:
[ ] Add a metaphor--a comparison of two objects, not using the words like, as, or than --For example, "The **glass jar became a prison** as I impatiently awaited my release from the science classroom."

Corrections in the Story:

[ ] Check for proper spelling of any work you think might be misspelled.
[ ] Check for proper punctuation.
[ ] Check for proper capitalization.

[ ] Check that you have used complete sentences.
[] Check that sentences begin with capital letters and end with appropriate punctuation.
[ ] Draw a line showing where the right-hand margin needs to be.
[ ] Write yourself a note if you forgot to skip a line under the title.
[] Check that you started a new paragraph with each new idea--For example, changes in the monarch's life stages, or changes in the setting. One page should not be just one paragraph--probably two or three!
[ ] If you used dialogue, check that you started a new paragraph each time a different character started speaking.
[ ] Eliminate all uses of the word **you** unless you have the characters speakin one another.

Group Editing

your editing group:

_____

_____

_____

Complete the following:

[ ] Read your story aloud for the group.
[ ] Have each person tell you one thing that could be improved.
[ ] Have each person tell you one thing he/she especially liked.
[ ] Trade papers and help each find additional errors in spelling, punctuation, capitalization, paragraphing, and sentence structure.
[ ] Help each other make certain the additional adjectives, adverbs, simile, personification, and alliteration were added.

Final Copy

Complete the following for your final copy:

1. Title Page: Use the plain paper your teacher gives you for your title page. Your title page needs to include the title of the story, your name, your English class period, the due date, and an illustration that you have either drawn and colored or found and neatly cut out and attached. You are also welcome to do a computer-generated title page.

2. Final Copy of Story: Neatly recopy your story on loose-leaf paper--front sides only --remembering to leave right- and left-hand margins. Do not write on the bottom two lines of any sheet. You do not need to use a proper heading; instead, put just your name and page number in the upper right-hand corner. If you would like to type or word process your story, you are welcome to do so, but **you must do the keyboarding yourself.** A note from home verifying that you personally typed the story must be turned in with your story.

3. Staple your final copy of the story behind the title page.

4. Staple your rough draft to the back of the Editing Instruction Sheets. You will submit your work in two separate piles.

Monarch Math

1. Using your map from social studies, develop a mileage key. How far did your Monarch actually travel?

2. A Monarch can cruise up to 25 mph. However, during an ideal day, a Monarch may advance only 50 miles. Based on question #1, how long will the migratory trip take?

3. A Monarch weighs (mass) only about .5 gram when it starts a journey. If there are 28 grams in an ounce, how many butterflies are in an ounce of Monarchs?

   In a pound of Monarchs?

4. At the end of the trip, the Monarch may weigh 5 times more than when it begins. How heavy is a flock of 5,000 Monarchs before and after the trip?

5. Researchers tell us that 200,000,000 Monarchs eventually will reach Mexico. What is the mass (weight) of this flock?

   in grams?

   in pounds?

   Remember, this is the <u>end</u> of the trip.

   Can you think of reasons why a Monarch is capable of cruising at 25 mph?

   Why do you think a Monarch weighs more at the end of the trip?